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Renal Function and Coronary Bypass Surgery in Patients With Ischemic Heart Failure

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Abstract

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Clinical Trial Registration: [Clinicaltrials.gov](https://clinicaltrials.gov); Identifier: NCT00023595

Declaration of Helsinki:

This study complies with the Declaration of Helsinki and locally appointed ethics committees have approved the research protocol. Informed consent has been obtained from patients.

Study Protocol and Consort Diagram

The study protocol of the STICH trial including a consort diagram has been published before ²⁵.

Objective: Chronic kidney disease (CKD) is a known risk factor in cardiovascular (CV) disease but its influence on treatment effect of bypass surgery (CABG) remains unclear. We assessed the influence of CKD on 10-year mortality and CV-outcomes in ischemic HF patients treated with medical therapy (MED) with or without CABG.

Methods: We calculated baseline estimated glomerular filtration rate (eGFR, CKD-EPI formula, CKD stages 1–5) from 1,209 patients randomized to MED or CABG in the Surgical Treatment for IsChemic Heart failure (STICH) trial and assessed its effect on outcome.

Results: In the overall STICH cohort, patients in CKD stages 3–5 were older than those in stages 1/2 (66–71 vs. 54–59 years) and had more comorbidities. Multivariable modeling revealed an inverse association between eGFR and risk of death, CV death and/or CV-rehospitalization (all $p < 0.001$, but not for stroke, $p = 0.697$). Baseline characteristics of the two treatment arms were equal for each CKD stage. There were significant improvements in death or CV-rehospitalization with CABG (Stage 1: HR 0.71, CI 0.53–0.96, $p = 0.02$; Stage 2: HR 0.71, CI 0.59–0.84, $p < 0.0001$; Stage 3: HR 0.76, CI 0.53–0.96, $p = 0.03$). These data were inconclusive in stages 4/5 for insufficient patient numbers ($N = 28$). There was no significant interaction of eGFR with the treatment effect of CABG ($p = 0.25$ for death and 0.54 for death or CV-rehospitalization).

Conclusions: Chronic kidney disease is an independent risk factor for mortality in patients with ischemic HF with or without CABG. However, mild to moderate CKD does not appear to influence long-term treatment effects of CABG.

Graphical Abstract:

Death or Cardiovascular rehospitalization at 10 years after randomization of STICH patients to either CABG or MED separated into the three CKD groups based on their eGFR. Note that CABG was superior to MED in patients with mild to moderate CKD.

CI: Confidence Interval; STICH: Surgical Treatment of IsChemic Heart failure; CV: Cardiovascular; CAD: Coronary Artery Disease; EF: Ejection Fraction; CKD: Chronic Kidney Disease; CABG: Coronary Artery Bypass Grafting; MED: Medical Treatment Group

Keywords

Chronic Kidney Disease; Survival; CABG treatment effect; medical therapy and Coronary Artery Bypass Grafting

INTRODUCTION

Chronic kidney disease (CKD) is a known risk factor in cardiovascular (CV) disease.^{1, 2} Several investigations demonstrate an independent effect of chronically impaired renal function on mortality in patients suffering from CAD and/or heart failure. In almost all large investigations assessing risk factors for cardiac surgery, CKD is one of the key factors.³⁻⁸ Thus, the question may arise whether the increased operative risk limits the potential benefits obtained from surgery.

In patients with coronary artery disease, coronary bypass grafting may be associated with an improvement in survival.^{9, 10} This survival effect is most visible in patients with severe coronary artery disease⁹ as well as in patients with systolic heart failure. The latter was demonstrated by us with the primary outcome of the Surgical Treatment for IsChemic Heart failure (STICH) trial.¹¹ In all of these investigations, CKD was associated with increased mortality. However, the direct impact of CKD on CABG's treatment effect has not yet been assessed in these trials. Thus far, only limited information is available mainly based on retrospective database analyses applying propensity risk adjustments.¹²⁻¹⁴ However, in real

life, the presence of CKD already appears to be a predictor for not referring patients to CABG.¹⁵

We therefore aimed to assess the influence of CKD on outcome in ischemic HF-patients included in the STICH trial treated with medical therapy (MED) with or without CABG.

METHODS

Study characteristics

STICH was a prospective, multicenter, randomized trial sponsored by National Heart, Lung, and Blood Institute (NHLBI) that enrolled 1212 individuals from 22 countries and 99 sites. STICH trial hypothesis 1 enrollment criteria, as well as the main results, have been published previously.^{11, 16} Briefly, patients with CAD and left ventricular ejection fraction (LVEF) 35% or less who were deemed suitable for surgical revascularization were randomized to CABG versus MED alone and followed-up for a median of 9.8 years after a protocol amendment to the initial planned 5 years follow-up. NHLBI and institutional review boards (IRB) from each participant site approved the protocol before trial start. All patients provided written informed consent.

Patient Grouping by CKD stage

We included 1,209 STICH patients with preoperative creatinine information. We calculated baseline estimated glomerular filtration rate (eGFR, CKD-EPI formula) and classified patients by established chronic kidney disease (CKD) stages. Stage 1 with eGFR ≥ 90 ml/min (n=232), Stage 2 with eGFR 60–89 ml/min (n=646), Stage 3 with eGFR 30–59 ml/min (n=303) and Stage 4/5 with eGFR <30 ml/min (n=28). Since the number of patients in the two treatment arms of CKD stages 4/5 were 12 and 16 and quickly fell below 10, we did not illustrate this group in the figures. The study was based on an intention to treat analysis. The crossover rate from MED to CABG was low with 10% in the first 12 months and was the same in both directions.¹⁷

Statistical Analysis

Baseline characteristics were summarized by eGFR stage. Categorical variables were reported as counts (percentages). Continuous variables were reported as median (25th, and 75th percentiles). Baseline comparisons across eGFR stage were conducted using general linear model for continuous variables and Cochran-Mantel-Haenszel for categorical variables. A Fine-Gray methodology¹⁸ for endpoints with the competing risk of death, such as CV death or CV hospitalization was utilized as non-CV death is considered as a competing risk for CV death (ie non-CV death would prohibit the occurrence of CV death, event of interest). While assessing stroke, the competing risk of all-cause death was taken into account. Adjusted Cox proportional model was generated. For continuous variables, we examined the relationships between individual variable and major clinical outcomes using a flexible model-fitting approach involving restricted cubic spline functions. These functions were graphically and statistically examined to assess the linearity of the relationship with the log hazard ratio. If this relationship is nonlinear, then shape will be characterized using a cubic-spline function¹⁹. eGFR was modeled with a cubic-spline function for CV

hospitalization endpoint.. For all other outcomes, eGFR was modeled in a linear fashion. The proportionality of the hazards in the Cox was checked and tested. The Kaplan-Meier time-to-event curves were utilized and presented. An interaction term of treatment and CKD stage was added to Cox model and tested using Wald statistic. In addition, we used the Andersen-Gill model with robust standard errors to account for correlated events within a patient²⁰ to analyze the association between eGFR and repeated CV rehospitalizations. All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Table 1 shows demographic data of the overall STICH cohort as well as separated by CKD stages. Of the 1209 patients, 610 were randomized to CABG and 599 to MED. Patients in CKD stages 3–5 were older and had more comorbidities. Comparing CABG to MED, there were no differences in the baseline characteristics between the two treatment arms for each CKD stage (see Supplementary Table 1). Table 2 shows the operative data of the patients having received bypass surgery. The majority of patients were operated using cardiopulmonary bypass (on-pump) and the number of grafts did not differ among CKD groups.

Figure 1 shows Kaplan-Meier estimates of all-cause mortality by CKD stage. Long-term mortality in CKD stage 3 was significantly higher compared to those in stages 1 and 2. It was worst in CKD stage 4/5 (data not shown for low patient numbers). Adjusted Cox regression model revealed an association between the risk of death and eGFR (HR=0.94, 95% CI 0.92–0.97, for each 5ml/min increase in GFR; $p<0.001$). The same was true for CV death and/or CV rehospitalization (both $p<0.001$) and for repeated CV rehospitalizations ($p<0.001$) but not for stroke ($p=0.169$). Creatinine alone also qualified as independent risk factor for mortality and for mortality and CV rehospitalization. Additional independent preoperative risk factors were age, gender, prior myocardial infarction, atrial fibrillation, moderate/severe mitral regurgitation, ejection fraction, body mass index, CCS angina class, and the number of diseased vessels.

The previously published primary outcome of the STICH trial demonstrated significant mortality reduction with CABG in the overall cohort (HR 0.84, CI 0.73–0.94, $p=0.02$).¹¹ Figure 2 shows Kaplan-Meier estimates for all-cause mortality in this population in CKD groups 1 (A) and 2 (B) and 3 (C) comparing patients with only medical treatment (MED) to those with additional bypass surgery (CABG). In CKD stages 2 and 3, there was a lower mortality associated with CABG over time, with significant risk reduction in CKD stage 2 (i.e. eGFR 60–89 ml/min, $p=0.01$). In patients with eGFR above 90 or below 30 ml/min, this difference was not apparent, but patient numbers and event rates were much lower. Interaction between treatment and CKD stages was tested using Wald statistic ($p=0.252$), indicating that renal function does not appear to interfere with CABG's treatment effect on all-cause mortality.

Figure 3 shows Kaplan-Meier estimates for death or CV rehospitalization in the same way as Figure 2. In this combined endpoint, CABG outperforms MED in all patients with an

eGFR above 30ml/min (i.e. CKD stages 1, 2 and 3). Interaction testing ($p=0.54$) again indicates that kidney function does not influence CABG's treatment effect on death or CV hospitalization. Further analyses assessing the influence of CKD stage on stroke and cardiovascular mortality also did not result in a significant interaction with p -values of 0.872 (stroke) and 0.967 (CV mortality).

Figures 4 shows spline curves of the MED and CABG groups for all cause death at 10 years (Figure 4A), all-cause death or cardiovascular hospitalization at 10 years (Figure 4B) and cardiovascular mortality (Figure 4C) as a function of eGFR. The curves graphically illustrate that patients with an eGFR above 30ml/min derive an outcome advantage from CABG. Interestingly, the CABG curve exceeds the MED curve for all-cause mortality at very low and very high eGFR values. This crossing is not apparent if the endpoint cardiovascular hospitalization is included and only happens at very high eGFR rates for the cardiovascular mortality endpoint.

DISCUSSION

We demonstrate in this secondary analysis of the STICH Trial that chronic kidney disease is an independent risk factor for mortality in patients with ischemic HF with or without CABG. However, mild to moderate CKD does not appear to influence the long-term treatment effect of CABG.

It is generally accepted that CKD is a risk for patients undergoing surgery.^{3–8} However, it is not clear whether this increased risk potentially limits the treatment effect of CABG. The evidence for a survival advantage of patients with complex coronary artery disease is accumulating^{9, 10, 21}. Thus, the role of CKD as risk factor is therefore becoming more relevant. Thus far, all studies are based on databank analyses and propensity matching. For instance, Roberts et al.¹³ report superior outcomes for CABG vs. PCI or medical therapy independent of eGFR. Interestingly, a large survival advantage for CABG was documented in diabetic patients with stable CAD.²² Many of these patients suffered from CKD. In addition, many of them had normal ejection fraction. Thus, the benefit of CABG does not seem to be limited to the presence low ejection fraction or CKD. Yet, in real life the presence of CKD appears to be an independent predictor of referral to PCI.¹⁵ We here report for the first time that mild to moderate CKD does not impair the treatment effect of CABG, an outcome that may be superior to PCI in many patients²³.

The independence of the CABG treatment effect from CKD can especially be seen when examining the secondary endpoints death or CV hospitalization and CV mortality. Even for mortality, the KM curves show a clear divergence in the groups with decent patient numbers (CKD stages 2 and 3). Thus, the results suggest that patients fulfilling the STICH inclusion criteria (primarily CAD amenable to CABG plus EF below 35%) are well advised with a recommendation for CABG if the eGFR is above 30ml/min. In addition, adapting off-pump techniques for bypass surgery may further improve surgical outcomes in the presence of CKD.²⁴

For patients with eGFR above 90 (CKD stage 1), the numbers are inconclusive. It is possible that kidney dysfunction is not measured appropriately by eGFR. CKD (specifically in diabetic patients) may be present despite high eGFR and is characterized by albuminuria⁵ which was not assessed in the STICH population. For patients with eGFR below 30ml/min (CKD stages 4 and 5), the numbers are too low to draw any meaningful conclusions. Here, other studies provide information possibly filling the gap. Bangalore et al. demonstrate in a large registry analysis comparing CABG to percutaneous intervention with modern drug eluting stents (EES) that CABG is superior to EES in preventing death even in dialysis patients.¹² In addition, Roberts et al.¹³ show (in the above quoted PCI vs CABG comparison in more than 5000 patients from a database) that even in patients of CKD stages 4 and 5, CABG appears superior to MED and PCI. In general, it appears that one should not shy away from CABG if CKD is present.

Limitations

The study had limited patient numbers in the highest and lowest CKD stages. Despite the fact that renal function was not part of the inclusion or exclusion criteria for the study, enrollment bias may have been responsible for the lower numbers of patients with advanced CKD. However, we still found significant variations of renal function in the enrolled patients. We therefore provide strong evidence that mild to moderate CKD does not limit CABG's treatment effect. However, since the STICH trial was not powered for interaction testing and residual confounding cannot truly be excluded, the conclusions have to be taken with caution.

CONCLUSION

We demonstrate in this analysis of the STICH Trial that CKD is an independent risk factor for mortality in patients with ischemic HF with or without CABG. However, mild to moderate CKD does not appear to influence the long-term treatment effect of CABG in patients with systolic heart failure amenable for CABG.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS

CABG	Bypass surgery
CAD	Coronary artery disease
CKD	Impaired renal function
CV	Cardiovascular
EES	Drug eluting stents

eGFR	Estimated glomerular filtration rate
HF	Heart failure
IRB	Institutional review boards
LVEF	Left ventricular ejection fraction
MED	Medical therapy
NHLBI	National Heart, Lung, and Blood Institute
PCI	Percutaneous coronary intervention
STICH	Surgical Treatment for IsChemic Heart failure

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CENTRAL MESSAGE

Mild to moderate chronic kidney disease does not limit the survival advantage afforded by CABG in heart failure patients with reduced ejection fraction.

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PERSPECTIVE STATEMENT

Chronic kidney disease (CKD) is a risk factor in surgery and CKD patients may not be offered surgery. However, the CKD impact on CABG treatment effect has never been assessed. We demonstrate, that in heart failure patients amenable for bypass surgery, the life prolonging effect of CABG is not affected by mild to moderate CKD.

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Figure 1:

Kaplan-Meier all-cause mortality estimates of the entire STICH population (MED and MED+CABG) separated into CKD stages 1,2 and 3. The figure includes statistical comparisons of the different CKD stages and also shows the number of patients at risk by CKD stage below. Note that the worse renal function, the higher is all-cause mortality. Patients in CKD stage 4/5 were omitted for low patient number (N=28).

CKD: Chronic Kidney Disease; CI: Confidence Interval; eGFR: estimated Glomerular Filtration Rate

Figure 2:

Kaplan-Meier all-cause estimates for all-cause mortality by treatment group separated into three panels with CKD stage 1 (**A**), CKD stage 2 (**B**) and CKD stage 3 (**C**). The figure also shows the N-values per group, number of events and 10 year mortality rate. The statistics (p-value and Hazard ratios) are univariate comparisons of CABG vs. MED for each group. MED: Medical Treatment Group; CABG: Coronary Artery Bypass Grafting; eGFR: estimated Glomerular Filtration Rate

Figure 3:

Kaplan-Meier estimates for death or cardiovascular hospitalization by treatment group separated into three panels with CKD stage 1 (A), CKD stage 2 (B) and CKD stage 3 (C). The figure also shows the N-values per group, number of events and 10 year mortality rate. The statistics (p-value and Hazard ratios) are univariate comparisons of CABG vs. MED for each group. The graphs have been truncated once the number of patients at risk were below 10.

MED: Medical Treatment Group; CABG: Coronary Artery Bypass Grafting; eGFR: estimated Glomerular Filtration Rate

Figure 4:

Spline curves illustrating the risk all cause death (A), death or cardiovascular hospitalization (B) and cardiovascular mortality (C) at 10 years for MED and CABG+MED patients as a function of the patients' eGFR. The shaded areas illustrate the confidence intervals. The interaction p-value reports the association of eGFR and treatment interaction with respect to each endpoint of interest. Note that CABG was superior to MED in all patients with an eGFR between 30 and 90 ml/min. The difference becomes larger if the combined endpoint of mortality plus cardiovascular rehospitalization or cardiovascular mortality was used. The lower and the upper end of the curves represent only few patients which is reflected by the broader confidence interval areas.

MED: Medical Treatment Group; CABG: Coronary Artery Bypass Grafting; eGFR: estimated Glomerular Filtration Rate

CONSORT Diagram STICH Trial

Table 1.

Baseline Characteristics by eGFR groups For Stich Hypothesis I Patients

Baseline Characteristics	All patients (N=1209)	Stage 1 (N=232)	Stage 2 (N=646)	Stage 3 (N=303)	Stage 4/5 (N=28)	P value
Randomized Treatment						0.5212
MED	599(49.5%)	115(49.6%)	314(48.6%)	154(50.8%)	16(57.1%)	
CABG	610(50.5%)	117(50.4%)	332(51.4%)	149(49.2%)	12(42.9%)	
Age (yrs)						<.0001
N	1209	232	646	303	28	
Median (25th, 75th)	59.7 (53.6, 67.2)	54.5 (50.0, 60.1)	58.9 (53.3, 66.2)	66.1 (58.7, 71.8)	70.7 (63.6, 75.2)	
Male	1061(87.8%)	208(89.7%)	575(89.0%)	256(84.5%)	22(78.6%)	0.0184
BMI						0.0069
N	1209	232	646	303	28	
Median (25th, 75th)	26.8 (24.0, 29.8)	25.9 (23.1, 28.7)	26.9 (24.2, 30.1)	27.4 (24.3, 30.0)	25.3 (23.7, 28.9)	
Hypertension	727(60.1%)	109(47.0%)	401(62.1%)	198(65.3%)	19(67.9%)	<.0001
Hyperlipidemia	729(60.4%)	123(53.0%)	394(61.2%)	193(63.7%)	19(67.9%)	0.0111
Diabetes	478(39.5%)	97(41.8%)	223(34.5%)	138(45.5%)	20(71.4%)	0.0124
Stroke	92(7.6%)	14(6.0%)	47(7.3%)	26(8.6%)	5(17.9%)	0.0647
Peripheral vascular disease	184(15.2%)	31(13.4%)	77(11.9%)	70(23.1%)	6(21.4%)	0.0005
Afib flutter	153(12.7%)	19(8.2%)	80(12.4%)	50(16.5%)	4(14.3%)	0.0062
Current Angina Class						0.0078
0	442(36.6%)	71(30.6%)	233(36.1%)	123(40.6%)	15(53.6%)	
I	185(15.3%)	28(12.1%)	102(15.8%)	53(17.5%)	2(7.1%)	
II	524(43.3%)	124(53.4%)	271(42.0%)	119(39.3%)	10(35.7%)	
III	48(4.0%)	9(3.9%)	31(4.8%)	8(2.6%)	0(0.0%)	
IV	10(0.8%)	0(0.0%)	9(1.4%)	0(0.0%)	1(3.6%)	
Current Angina Class >=II	582(75.9%)	133(82.6%)	311(75.3%)	127(70.6%)	11(84.6%)	0.0319
Current NYHA						0.0050
I	138(11.4%)	27(11.6%)	89(13.8%)	20(6.6%)	2(7.1%)	
II	625(51.7%)	130(56.0%)	334(51.7%)	148(48.8%)	13(46.4%)	
III	411(34.0%)	71(30.6%)	205(31.7%)	123(40.6%)	12(42.9%)	
IV	35(2.9%)	4(1.7%)	18(2.8%)	12(4.0%)	1(3.6%)	
LVEF (%)						0.0325
N	1209	232	646	303	28	
Median (25th, 75th)	27.0 (21.8, 33.0)	28.0 (22.9, 35.0)	27.0 (21.1, 33.0)	26.1 (21.2, 33.8)	25.5 (21.3, 31.6)	
Moderate Severe MR	219(18.2%)	40(17.2%)	113(17.5%)	60(19.9%)	6(21.4%)	0.3374
3 vessel / stenosis >=75%	441(36.5%)	79(34.1%)	211(32.7%)	138(45.5%)	13(46.4%)	0.0014
Creatinine (mg/dL)						<.0001
N	1209	232	646	303	28	
Median (25th, 75th)	1.1 (0.9, 1.3)	0.8 (0.7, 0.9)	1.1 (1.0, 1.2)	1.4 (1.3, 1.6)	2.5 (2.2, 3.1)	

Baseline Characteristics	All patients (N=1209)	Stage 1 (N=232)	Stage 2 (N=646)	Stage 3 (N=303)	Stage 4/5 (N=28)	P value
Hemoglobin (g/dL)						<.0001
N	1209	232	646	303	28	
Median (25th, 75th)	13.9 (12.7, 14.9)	13.9 (13.0, 15.1)	14.0 (12.8, 15.0)	13.6 (12.3, 14.5)	12.5 (11.8, 13.6)	
Mitral Valve Procedure	63(12.4%)	13(12.7%)	35(12.8%)	13(10.6%)	2(22.2%)	0.8732
Previous PCI	156(12.9%)	33(14.2%)	78(12.1%)	41(13.5%)	4(14.3%)	0.9634
Previous CABG	36(3.0%)	6(2.6%)	20(3.1%)	9(3.0%)	1(3.6%)	0.7759
Number of diseased vessels (75%)						0.0047
0	25(2.1%)	1(0.4%)	17(2.6%)	6(2.0%)	1(3.6%)	
1	282(23.3%)	64(27.6%)	154(23.9%)	56(18.5%)	8(28.6%)	
2	460(38.1%)	88(37.9%)	263(40.8%)	103(34.0%)	6(21.4%)	
3	441(36.5%)	79(34.1%)	211(32.7%)	138(45.5%)	13(46.4%)	
Left Main Stenosis >=50%	32(2.6%)	2(0.9%)	13(2.0%)	15(5.0%)	2(7.1%)	0.0007
Proximal LAD Stenosis >=75%	823(68.1%)	168(72.4%)	435(67.4%)	207(68.3%)	13(46.4%)	0.0666
Baseline ESVI (mL/m ²)						0.4944
N	1112	219	596	277	20	
Median (25th, 75th)	77.7 (59.7, 99.9)	77.9 (57.4, 99.9)	79.0 (61.9, 100.8)	75.9 (58.2, 99.0)	73.5 (66.4, 89.0)	
Baseline EDVI (mL/m ²)						0.2688
N	951	185	511	235	20	
Median (25th, 75th)	111.0 (89.5, 135.4)	113.2 (89.6, 138.3)	112.1 (89.2, 137.2)	108.3 (88.2, 134.1)	103.4 (93.3, 116.8)	
Baseline eGFR (mL/m ²)						<.0001
N	1209	232	646	303	28	
Median (25th, 75th)	71.6 (58.6, 85.8)	97.9 (94.0, 102.9)	73.7 (67.3, 81.1)	51.3 (44.1, 56.1)	24.8 (17.4, 28.4)	
On Pump(CABG pts only)						0.1126
No	116(20.9%)	30(27.5%)	60(20.0%)	23(16.9%)	3(30.0%)	
Yes	439(79.1%)	79(72.5%)	240(80.0%)	113(83.1%)	7(70.0%)	

Stage 1: eGFR >=90 mL/min.

Stage 2: eGFR 60=<90 mL/min

Stage 3: eGFR 30-<60 mL/min

Stage 4: eGFR <30 mL/min

Table 2.**Operative Data**

Baseline Characteristics	All patients (N=610)	Stage 1 (N=117)	Stage 2 (N=332)	Stage 3 (N=149)	Stage 4/5 (N=12)	P value
Number of Conduits						0.2676
0	2(0.4%)	0(0.0%)	2(0.7%)	0(0.0%)	0(0.0%)	
1	69(12.4%)	13(11.9%)	35(11.6%)	17(12.5%)	4(40.0%)	
2	175(31.4%)	29(26.6%)	98(32.5%)	45(33.1%)	3(30.0%)	
3	236(42.4%)	47(43.1%)	130(43.0%)	57(41.9%)	2(20.0%)	
4	68(12.2%)	19(17.4%)	34(11.3%)	14(10.3%)	1(10.0%)	
5	5(0.9%)	1(0.9%)	3(1.0%)	1(0.7%)	0(0.0%)	
>=6	2(0.4%)	0(0.0%)	0(0.0%)	2(1.5%)	0(0.0%)	
Total Number of Distal anastomoses						0.3898
0	9(1.6%)	0(0.0%)	6(2.0%)	3(2.2%)	0(0.0%)	
1	63(11.3%)	12(11.0%)	31(10.3%)	16(11.8%)	4(40.0%)	
2	128(23.0%)	22(20.2%)	75(24.9%)	28(20.6%)	3(30.0%)	
3	221(39.7%)	44(40.4%)	116(38.5%)	59(43.4%)	2(20.0%)	
4	98(17.6%)	22(20.2%)	53(17.6%)	22(16.2%)	1(10.0%)	
5	32(5.8%)	8(7.3%)	19(6.3%)	5(3.7%)	0(0.0%)	
>=6	5(0.9%)	1(0.9%)	1(0.3%)	3(2.2%)	0(0.0%)	
Procedure on Mitral Valve Performed	63(12.4%)	13(12.7%)	35(12.8%)	13(10.6%)	2(22.2%)	0.8732
Cardioplegia						0.0780
None	151(27.3%)	36(33.3%)	79(26.3%)	33(24.4%)	3(30.0%)	
Crystalloid	122(22.1%)	27(25.0%)	70(23.3%)	24(17.8%)	1(10.0%)	
Blood	265(47.9%)	42(38.9%)	143(47.7%)	74(54.8%)	6(60.0%)	
Both	15(2.7%)	3(2.8%)	8(2.7%)	4(3.0%)	0(0.0%)	
Acuteness of Operation						0.0366
Elective	530(95.3%)	105(96.3%)	288(95.7%)	129(94.9%)	8(80.0%)	
Urgent	21(3.8%)	3(2.8%)	12(4.0%)	5(3.7%)	1(10.0%)	
Ongoing ischemia	3(0.5%)	1(0.9%)	1(0.3%)	1(0.7%)	0(0.0%)	
Hemodynamic instability	2(0.4%)	0(0.0%)	0(0.0%)	1(0.7%)	1(10.0%)	
On Pump	439(79.1%)	79(72.5%)	240(80.0%)	113(83.1%)	7(70.0%)	0.1126

Stage 1: eGFR >=90 mL/min.

Stage 2: eGFR 60=<90 mL/min

Stage 3: eGFR 30-<60 mL/min

Stage 4: eGFR <30 mL/min